ABSTRACT

The strength and stability of the soil surface need to be define before any construction begin. The purposes of this study are to obtain the basic characteristic and shear strength of silty clay at the some location in Temerloh district. It has low compressibility and most of the structure constructed on it usually will be affected especially in stabilization and settlement. In order to prevent that from happen, the engineering properties of silty clay must be determined before the beginning of any design work. In this study, some disturbed samples of silty clay were required, taken from 2 different locations which are Kg Buntut Pulau and Kg. Sanggang for soil identification, classification and properties test. For the determination of basic properties of that silty clay, a laboratory test of sieve analysis and Atterberg Limit were conducted in order to get the relationship between moisture content, liquid limit and plasticity index of every sample. Then, the Unconsolidated-Undrained test was choosed as the suitable method of Triaxial Test for determining shear strength parameters for the silty clay. From the result, the moisture content of the sample from both sites is 34.52% and 50.8% respectively. Meanwhile, for the Atterberg limit result, both site recorded the reading of 51.10% and 54.87% respectively for liquid limit and also 25.31% and 28.78% for the plastic limit. Then the value of plasticity index which obtain form the liquid and plastic limit is 25.79% and 26.09%. Then for the particle size distribution test, site A was recorded percentage of silt and clay as the highest with 51% and for same as for site B with 56% of silt and clay for the most dominant particle. The shear strength test results have clearly shown the weakness of Kg Buntut Pulau and Kg. Sanggang soil which are within soft clay soils strength with the average recorded value of 37.91kPa and 26.41kPa respectively. The data and result from this project can be used as a preliminary forecast for further investigation of soil properties and shear strength in the future construction and development.

ABSTRAK

Kekuatan dan kestabilan permukaan tanah tersebut mesti ditakrif terlebih dahulu sebelum pembinaan bermula. Tujuan kajian ini dijalankan adalah untuk mendapatkan ciri-ciri asas dan kekuatan ricih tanahliat berkelodak di sesetengah lokasi di daerah Temerloh. Ia mempunyai kebolehmampatan yang rendah dan kebanyakan struktur yang dibina di atasnya kebiasaanya akan dipengaruhi oleh kestabilan dan kemendapan. Untuk mengelakkan kejadian seumpama itu berlaku, sifat kejuruteraan tanah liat berkelodak mesti ditentukan sebelum kerja rekaan bermula. Dalam kajian ini, sedikit sampel tanah liat berkelodak terkacau diperlukan yang diambil dari 2 lokasi berbeza iaitu Kg Buntut Pulau dan Kg. Sanggang untuk penentuan, pengkelasan dan ciri-ciri tanah. Untuk penentuan ciri-ciri asas tanah liat berkelodak ini, ujian makmal yang merangkumi ujian taburan partikel tanah dan had Atterberg dijalankan untuk mendapatkan hubungan antara kandungan air, had cecair dan indeks keplastikan setiap sampel. Ujian ketidakmendapan-ketidakaliran sebagai kaedah yang sesuai untuk ujian kekuatan ricih untuk penentuan parameter kekuatan ricih tanah liat berkelodak. Daripada keputusan, kandungan air untuk kedua-dua tempat ialah 34.52% dan 50.8%. Untuk keputusan ujian had Atterberg pula, kedua-dua tempat mencatatkan nilai 51.10% dan 54.87% untuk had cecair dan juga 25.31% dan 28.78% untuk had plastik. Untuk ujian taburan partikel tanah pula, tempat A mencatatkan peratus tanah kelodak dan tanah liat sebagai yang tertinggi dengan 51% begitu juga dengan tempat B 56% untuk tanah kelodak dan tanah liat sebagai partikel tanah yang paling dominan. Ujian terhadap kekuatan ricih tanah menunjukkan kelemahan yang ketara terhadap kekuatan ricih tanah tersebut iaitu di dalam lingkungan bacaan kekuatan bagi tanah liat lembut dengan bacaan purata 37.91kPa dan 26.41kPa. Segala data dan keputusan yang diperoleh daripada ujian-ujian di dalam kajian ini dapat digunakan sebagai ramalan awal untuk kajian ciri-ciri asas dan kekuatan ricih yang lebih lanjut untuk pembinaan masa hadapan.

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S	-	Shear strength
c'	-	effective stress cohesion intercept
Θ'	-	effective stress angle of friction
w, MC	-	moisture content
PL	-	plastic limit
PI	-	plasticity index
LL	-	liquid limit
c_u	-	shear strength

CHAPTER 1

INTRODUCTION

1.1 Introduction

Malaysia has mission to be one of the modern and sophisticated countries in the world as stated in Wawasan 2020. Recently, this scenario caused a lot of massive development in our country. There are a lot of mega structures and skyscrapers which have been magnificently constructed all over the place in Malaysia such as PETRONAS Twin Tower, Kuala Lumpur International Airport (KLIA) and many more. Lately, engineers are so eager to get more money which effectuates them to do constructions without considering the quality of the soil. Consequently, there are some constructions turns out to be a disaster since they were built at low quality soil structure. But, many said it caused by natural disasters and no one could blame the engineers. Actually, there are many factors related to the failure of a project, which is mainly caused by natural disaster and due to development activities surrounding those areas. But one of the factors which also become the reason of a soil failure is the strength of the soil itself.

In order to build a good construction project in this industry, we have to consider some factors that could affect the project. The most important thing that we need to think about is the condition of the chosen site. The main aspect that related to site condition is the condition of the soil. When a construction project needs to develop, type of soil at the area will be the most important element to be considered. Many soils have prove to be problematic in geotechnical engineering because of the way they expand, collapse, disperse, undergo excessive settlement and have a distinct lack of strength (Fauziah, 2007). The strength and stability of the soil surface needs to be defined before begin any construction by doing some experiments.

The purposes of this study are to obtain the basic properties and shear strength of silty clay at some location in Temerloh district in Pahang. Silty clay is defined as a clay type soil which has the combination of silt soil and the percentage of clay soil itself was greater than silt respectively. It has low compressibility and most of the structure constructed on it usually will be affected especially in stabilization and settlement. To prevent it from occur, the engineering properties of silty clay must be determined before design work start. Therefore, geotechnical engineer may avoid any problems related to construction on the soft soil. The most critical silty clay problem is the differential settlement which will cause the building to crack and provide other types of destruction as well. That is why the research related to this type of soil needs to be continued as the data and result from this project can be used as a guideline for further investigation of soil properties and shear strength in the future construction and development especially in Temerloh district.

1.2 Objective

The objectives of this study are as follow:

i. To determine the basic properties of Temerloh silty clay.
ii. To determine the shear strength of Temerloh silty clay.

1.3 Scope of Study

This study is conducted at some locations in Temerloh, Pahang Darul Makmur. It is one of the famous districts in Pahang because of its “Gulai Tempoyak Ikan Patin” which located near to Pahang River, the longest river in peninsular of Malaysia. Since it is just a stone throw away to Pahang River, most of the soil in this town is found to be silty clay. That is why this place was chosed for the study. This study only focuses on determination of the basic properties and shear strength of silty clay soil. All the testing for this study is conducted in laboratory by using British Standard 1377:1990 as a reference.

Figure 1.1: Study Location at Temerloh (www.ppdbera.net).

1.4 Problem Statement

Malaysia is growing as a development country throughout the years. Due to development of our country, construction industry become more rapid and the use of soft soil area like silty clay in Malaysia is increasing as the other land with the better soil condition is decreasing. Because of this, some problem occurred regarding to the use of silty clay on construction such as the stability and settlement of the soil. There are many cases happen due to failure of the building occur because the area which contain of the silty clay are not reinforced with proper ground improvement technique. Because of that, we need to do more investigation on the characteristic and strength of the soil with the hope that it can help engineers to design better structures on silty clay and reduce any failure.

1.5 Importance of Study

This study is so important to overcome the problem of the silty clay soil in construction especially in Temerloh, Pahang. In this study, the basic properties and shear strength of silty clay soil in Temerloh will be determined by some laboratory testing such as moisture content, sieve analysis, Atterberg limit and Unconsolidated Undrained Test. This study is also important because many of location in Pahang are not much explore by engineers, especially at Temerloh district. Hopefully, the outcomes will become a part of data of silty clay soil in Pahang. The result from this study can be referred by engineers as useful guideline for them to apply in construction on silty clay soil.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The development of construction project on silty clay area was increasing lately due to insufficient of other suitable area. Silty clay commonly occurs as soft, wet unconsolidated surficial deposits that are integral parts of the wetlands systems (Edward, 2006). They are known as problematic soils, with high compressibility and low shear strength. Silty clay usually present at the location which is nearer to river area all over the world. All building or construction project built on this type of soils normally faces with the crisis of weak foundation soil conditions. But still, this type of soil have chosen to be develop because there no longer an option to choose the suitable ground. The most important aspect is the best and strategic areas which been looking by some engineers to construct a structure.

Silt soils represent the excessive form of soft soil in Malaysia. If it is possible, engineers would avoid silty soil as the foundation beneath their structure or construction project. They are difficult to sample and test using normal soil techniques and in fact there is less adequate engineering system in place for classifying these soils (Edward, 2006).

The data relate to soil properties are composed during the soil analysis at site. Site survey work is needed and extremely important in order to get the detail about any site before construction begin. Soil characteristic was the first thing need to be determined by field inspection of the soil and by laboratory testing of some group of selected soil.

2.2 Soil Classification

Soil classification is carried out in order to define a small number of different groups of soil on any site. Each soil group may consist of a stratigraphically defined geological unit of a site. Particle size, plasticity and organic content may be more important to the geotechnical engineer than time of deposition. The three main tools used to classify soil are soil description, particle size distribution analysis and plasticity testing (Whitlow, 2001)

Soil classification, although introducing a further stage of data acquisition into site investigation, has an important role to play in reducing the costs and increasing the cost-effectiveness of laboratory testing. Classification tests allow the soils on a site to be divided into a limited number of random groups, each of which is estimated to contain materials of similar geotechnical properties.

Different soils with similar properties may be classified into groups and sub-groups according to their engineering behavior (Das, 2006). Currently, there are two major soil classification systems are available for general engineering use which are American Association of State Highway and Transportation Officials (AASHTO) classification system and the Unified Soil Classification System (USCS). Both systems take into consideration the particle-size distribution and Atterberg limits for their classification.

Atkinson (2007) mentions that, it is important to distinguish between soil description and soil classification. Description is simply what can see with the eyes and how the soil responds to simple test. A classification is a scheme for separating soils into broad groups, each with broadly similar behavior.

An engineering soil classification system is only useful for feature applications. In the constructions of important soil structures the classification must be supplemented by laboratory tests other than those needed for classification. The experiment is made using disturbed samples recovered from site as well as undisturbed samples from boreholes and excavations (Aysen, 2005).

According to Atkinson (2007), there are various classifications schemes for different purpose; there are agricultural classifications (Figure 2.1) based on how soils support crops and geological classifications (Figure 2.2) based on the age of the deposit or nature of the grains. For civil engineering purposes soil classifications should be based mainly on mechanical behaviour.

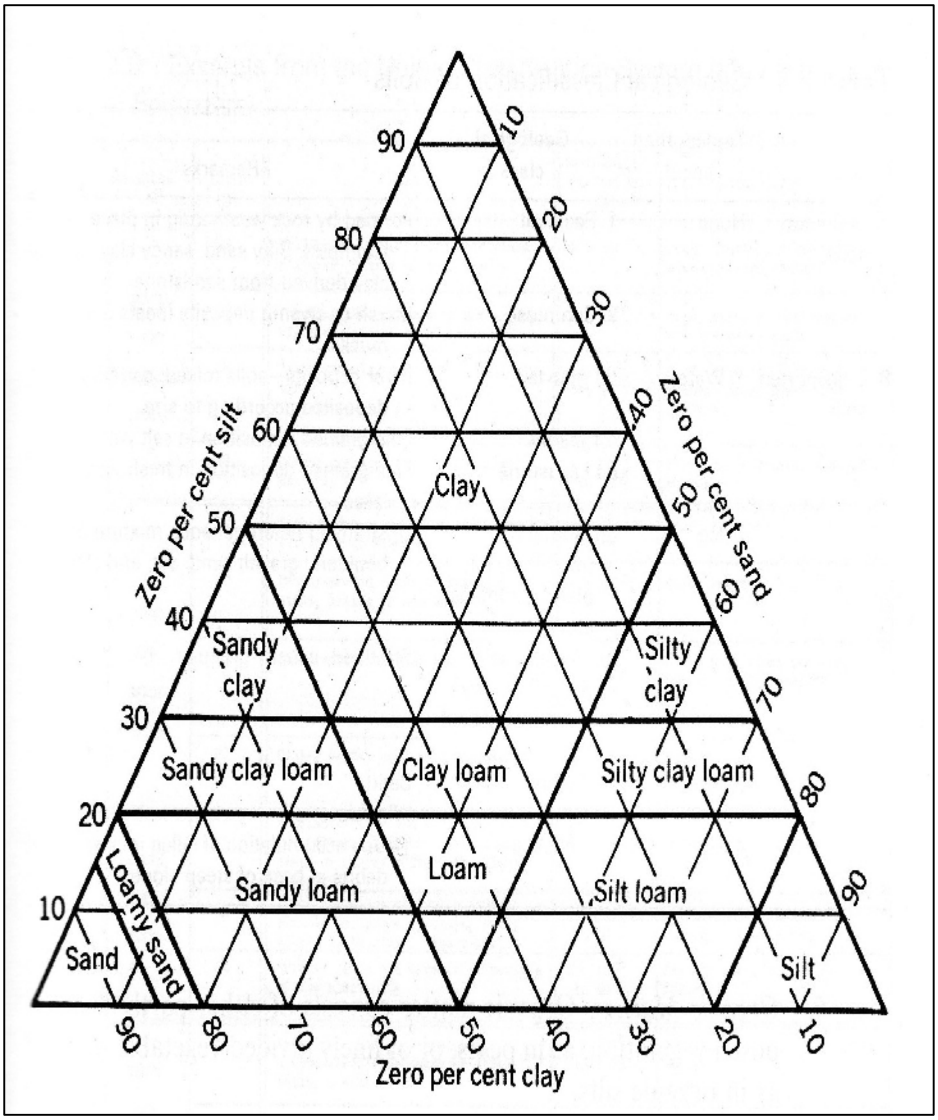

Figure 2.1: Agricultural Classification of Soil (Das, 2001).

Group	Transporting agent	Geological class	Remarks
A. Sedentary soils	None	1. Residual	Formed by rock weathering in place. Examples: Silty sand, sandy clay, or silty clay derived from sandstone.
		2. Cumulose	Marsh or swamp deposits (peats and mucks).
B. Transported soils	1. Water	(a) Alluvial	River deposits—soils mixed, sorted, and deposited according to size.
		(b) Marine	Fine-grained deposition in salt water.
		(c) Lacustrine	Fine-grained deposition in fresh water lakes.
	2. Ice	(a) Glacial till (moraines, till plains, drumlins, etc.)	Unstratified heterogeneous mixture of boulders, gravel, sand, silt, and clay.
		(b) Fluvio-glacial deposits (eskers, terraces, outwash plains, etc.)	Stratified, usually granular.
	3. Wind	(a) Dunes	Sand.
		(b) Loess	Windblown silt.
	4. Gravity	(a) Colluvial	Talus—accumulation of fallen rock and rock debris at base of steep slopes.

Figure 2.2: Geological Classification of Soils (Das, 2001).

2.2.1 AASHTO Classification System

According to Das (2006), the AASHTO Soil Classification System (Figure 2.3) was developed by the American Association of State Highway and Transportation Officials in 1929 as the Public Road Administration classification system. It is used as a guide for the classification of soils and soil-aggregate mixtures for highway construction purposes. The classification system was first developed in 1929, but has been revised several times since then, with the present version proposed by the Committee on Classification of Materials for Sub-grades and Granular Type Roads of the Highway Research Board in 1945 (ASTM designation D-3282; AASHTO method M145).

General Classification	Granular Materials (35% or less passing the 0.075 mm sieve)							Silt-Clay Materials (>35% passing the 0.075 mm sieve)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis, % passing											
2.00 mm (No. 10)	50 max	...	...	...	...	...	...	...	...	...	...
0.425 (No. 40)	30 max	50 max	51 min	...	...	...	...	...	...	...	...
0.075 (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)											
Liquid Limit	...		...	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity Index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min[1]
Usual types of significant constituent materials	stone fragments, gravel and sand		fine sand	silty or clayey gravel and sand				silty soils		clayey soils	
General rating as a subgrade	excellent to good							fair to poor			

Figure 2.3: AASHTO Soil Classification System (from AASHTO M 145 or ASTM D3282).

2.2.2 Unified Soil Classification System

The Unified Soil Classification System (USCS) as shown in Figure 2.4 below was originally proposed by Casagrande in 1942 and then was revised in 1952 by the Corps. of Engineers and the U.S. Bureau of Reclamation (Das, 2001). At present, it was commonly used by geotechnical engineers, various organizations and building codes. There are two categories which classifies soils in this system which is:

a) Coarse grained soils that are generally and sandy in nature with less than 50% passing through the No. 200 sieve. The group symbols start with a prefix of G or S. G stands for gravel or gravelly soil, and S for sand or sandy soil.

b) Fine-grained soils are with 50% or more passing through the No. 200 sieve. The group symbols start with prefixes of M, which stands for inorganic silt, C for inorganic clay, or O for organic silts and clays. The symbol Pt is used for peat, muck, and other highly organic soils.

Other symbols used for the classification are shown in Table 2.1 below.

Table 2.1: Symbol for Soil Classification.

Symbol	Description
W	well graded
P	poorly graded
L	low plasticity (liquid limit less than 50)
H	high plasticity (liquid limit more than 50)

Criteria for assigning group symbols				Group symbol
Coarse-grained soils More than 50% of retained on No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[a]	$C_u \ge 4$ and $1 \le C_c \le 3$[c]	GW
			$C_u < 4$ and/or $1 > C_c > 3$[c]	GP
		Gravels with Fines More than 12% fines[a,d]	$PI < 4$ or plots below "A" line (Figure 3.2)	GM
			$PI > 7$ and plots on or above "A" line (Figure 3.2)	GC
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[b]	$C_u \ge 6$ and $1 \le C_c \le 3$[c]	SW
			$C_u < 6$ and/or $1 > C_c > 3$[c]	SP
		Sands with Fines More than 12% fines[b,d]	$PI < 4$ or plots below "A" line (Figure 3.2)	SM
			$PI > 7$ and plots on or above "A" line (Figure 3.2)	SC
Fine-grained soils 50% or more passes No. 200 sieve	**Silts and clays** Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line (Figure 3.2)[e]	CL
			$PI < 4$ or plots below "A" line (Figure 3.2)[e]	ML
		Organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$; see Figure 3.2; OL zone	OL
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line (Figure 3.2)	CH
			PI plots below "A" line (Figure 3.2)	MH
		Organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$; see Figure 3.2; OH zone	OH
Highly Organic Soils	Primarily organic matter, dark in color, and organic odor			Pt

[a] Gravels with 5 to 12% fine require dual symbols: GW-GM, GW-GC, GP-GM, GP-GC.

[b] Sands with 5 to 12% fines require dual symbols: SW-SM, SW-SC, SP-SM, SP-SC.

[c] $C_u = \dfrac{D_{60}}{D_{10}}$; $C_c = \dfrac{(D_{30})^2}{D_{60} \times D_{10}}$

[d] If $4 \le PI \le 7$ and plots in the hatched area in Figure 3.2, use dual symbol GC-GM or SC-SM.

[e] If $4 \le PI \le 7$ and plots in the hatched area in Figure 3.2, use dual symbol CL-ML.

Figure 2.4: Unified Soil Classification System (Aysen, 2005).

2.2.3 Classification Based on Plasticity

The engineering behavior between coarse-grained soil and fine-grained soil has a clear division between themselves. The engineering behavior of a coarse-grained soil is based on grain size distribution while fine-grained soil is based on plasticity characteristic (Day, 1999).

Figure 2.5 show an alternate classification system known as the inorganic soil classification based on plasticity (ISBP). According to the ISBP, a nonplastic soil is defined as a soil where the minus No. 40 fraction cannot be rolled at any water content, or the plastic limit is equal to or greater than the liquid limit (Day, 1999). For plastic soils, the subdivisions are based on plasticity characteristics (LL and PI) while for the nonplastic soils, the subdivisions are based on grain size distributions.

The ISBP classification system has the advantage which is the soil is generally arranged from the best to worst inorganic coil type in terms of shear strength, compressibility and expansion potential. It is also does not have dual symbols. Meanwhile the disadvantage of this system is that it does not include organic soils, but they should probably be separately classified because of their unique engineering properties.

Major divisions (1)	Subdivisions (2)	ISBP symbol (3)	Typical names (4)	Laboratory classification criteria (5)
Nonplastic soils	Gravels (Greater fraction of total sample is retained on No. 4 sieve)	GW	Well-graded gravels, sandy gravels, silty-sandy gravels	$C_u \geq 4$ and $1 \leq C_c \leq 3$
		GP	Poorly graded gravels, gravel-sand-silt mixtures	Does not meet C_u and/or C_c criteria listed above. In addition, the % passing No. 200 sieve < 15%
		GM	Poorly graded, nonplastic silty gravels, gravel-silt mixtures	Does not meet C_u and/or C_c criteria listed above. In addition, the % passing No. 200 sieve ≥ 15%
	Sands (Greater fraction of total sample is between No. 4 and No. 200 sieves)	SW	Well-graded sands and gravelly sands	$C_u \geq 6$ and $1 \leq C_c \leq 3$
		SP	Poorly graded sands or sand-gravel-silt mixtures	Does not meet C_u and/or C_c criteria listed above. In addition, the % passing No. 200 sieve < 15%
		SM	Poorly graded, nonplastic silty sands, sand-silt mixtures	Does not meet C_u and/or C_c criteria listed above. In addition, the % passing No. 200 sieve ≥ 15%
	NP silt	MN	Nonplastic silts, rock flour. Gravelly silts and sandy nonplastic silts	Greater fraction of the total sample passes the No. 200 sieve. Silts are nonplastic
Plastic soils	Plastic silts (Minus No. 40 fraction plots below A-line)	GM*	Plastic silty gravels, gravel-silt mixtures	50% or more particles retained on the No. 200 sieve with the greater fraction of gravel size
		SM*	Plastic silty sands, sand-silt mixtures	50% or more particles retained on the No. 200 sieve with the greater fraction of sand size
		ML MI MH	Plastic silts, sandy silts, and clayey silts	For silt of low plasticity (ML) PI ≤ 10 For silt of intermediate plasticity (MI) 10 < PI ≤ 30 For silt of high plasticity (MH) PI > 30
	Clays (Minus No. 40 fraction plots on or above A-line)	GC*	Clayey gravels, gravel-clay mixtures	50% or more particles retained on the No. 200 sieve with the greater fraction of gravel size
		SC*	Clayey sands, sand-clay mixtures	50% or more particles retained on the No. 200 sieve with the greater fraction of sand size
		CL CI CH	Clay, sandy clays, and silty clays	For clay of low plasticity (CL) PI ≤ 10 For clay of intermediate plasticity (CI) 10 < PI ≤ 30 For clay of high plasticity (CH) PI > 30

Figure 2.5: Inorganic Soil Classification Based on Plasticity, ISBP (Day, 1999).

2.3 Soil Description

Soil description is basically what can see with the eyes and how the soil responds to simple tests (Atkinson, 2007). It is helpful to have a simple system to describe the fundamental features. There are several methods published in National Standard and to some extent, these reflect the characteristics of the most common soils in the county. A simple and universal scheme for soil description is as follow:

a) The nature of the grains – The most important features of soil grains are their size and the grading, together with the shape and surface texture of the grains and their mineralogy.

b) The current state of the soil – The important indicators of the state of a soil is the current stresses, the current water content and the history of loading and unloading. These are reflected by the relative strengths and stiffnesses of samples of the soil.

c) The structure of the soil – This consists of fabric and bonding. Natural soils are rarely uniform and they contain fabric features, such as layers, which are seen in small samples and in large exposures. In some natural soils the grains are weakly bond together. If the grains are strongly bonded material has become a rock.

d) The formations of the soil – Soils are formed in different ways. They may be deposited naturally from water, ice or wind; they may be the residual products of rock weathering; they may be compacted by machines into embankments and fills.